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ABSTRACTS OF PAPERS

Eighteenth Annual Albert L. Tester Memorial Symposium, 22–23 April 1993[1]

The Albert L. Tester Memorial Symposium is held in honor of Professor Albert L. Tester, who, at the time of his death in 1974, was senior professor of zoology at the University of Hawaii. The faculty and students of the Department of Zoology proposed an annual symposium of student research papers as a means of honoring, in a continuing and active way, Dr. Tester's lively encouragement of student research in a broad range of fields in marine biology. Papers reporting original research on any aspect of biology are solicited from students at the university, and these papers are presented at the symposium, which takes place during the spring semester. Income from contributions to the Albert L. Tester Memorial Fund of the University of Hawaii Foundation is used to provide two prizes for the best papers by graduate students. Papers are judged on quality, originality, and importance of research reported, as well as on the quality of the public presentation. Judges include several members of the faculty of the Department of Zoology as well as winners of the symposium from the preceding year, when possible. In addition, a distinguished scholar from another university is invited to participate in the symposium as a judge and to present the major symposium address. This year Stephen L. Hubbell of Princeton University participated in the symposium.

Spawning Grounds of the Neon Flying Squid, *Ommastrephes bartramii*, near the Hawaiian Archipelago[2]

JOHN R. BOWER[3]

Squids of the family Ommastrephidae are among the largest and most numerous cephalopods in the open ocean and are the basis for major squid fisheries worldwide. The neon flying squid, *Ommastrephes bartramii*, occupies waters in the North Pacific near the Subarctic Boundary during summer and fall, where the species has been targeted by international driftnet fishing fleets. At the beginning of winter, *O. bartramii* migrates south to spawn. Despite the importance of this species, little is known about where it spawns or the characteristics of its spawning grounds. Planktonic young (paralarvae) of *O. bartramii* recently have been found in early spring along the Hawaiian Archipelago, suggesting that spawning is related to the position of the island chain. Synoptic plankton surveys orthogonal to the Hawaiian Archipelago were conducted in 1991 and 1992 to determine the spatial distribution of paralarvae. Estimation of age and batch dates were inferred from analysis of statolith microstructures of the young. Spawning sites were then estimated from hatch dates by back-calculating with physical data on the speed and direction of ocean currents near the archipelago. Data analyzed thus far do not support the hypothesis that the location of spawning is related to the position of the Hawaiian Archipelago.

[1] Manuscripts accepted 30 April 1993.

[2] Department of Oceanography, University of Hawaii at Mānoa, Honolulu, Hawaii 96822.

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Laboratory Culture and Larval Development of the Peppermint Shrimp, *Lysmata wurdemanni* (Caridea: Hippolytidae)[4]

W. DOUGLAS CROMPTON[5]

Lysmata wurdemanni Gibbes females collected from rock jetties at Port Aransas, Texas, spawned yearround in 76-liter aquaria at the University of Texas Marine Science Institute (UTMSI). Females brooded eggs on pleopods for 9 days (27°C) to 11 days (25°C), molted within 24 hr of hatch, and extruded a subsequent clutch. Mean clutch size was 1202 hatched larvae (range, 519–1707). A flow-through "downwelling" system, developed at UTMSI, was successful for culturing larvae through to the postlarval stage. Larvae hatched as zoea and were reared through seven zoeal and one postlarval stages. Salinity and water temperature during rearing ranged from 30 to 36 ppt and 25–27°C; the larvae were fed *Artemia salina*. Duration of planktonic larval stage ranged from 30 to 67 days before metamorphosis. A description of the developmental stages is given.

Point Mutations Affect Gating of Rat Brain IIA Sodium Channel[6]

ANDREA FLEIG[7]

Sodium channels are voltage-gated transmembrane proteins propagating electrical signals in neurons and heart and skeletal muscle cells. Cloning and subsequent expression in heterologous systems has yielded structure-function information about wildtype and mutant Na channels. The protein's α subunit has four homologous and highly preserved domains (I–IV), each consisting of six transmembrane segments. The fourth segment (S4) of each domain carries evenly spaced and positively charged amino acids and has been proposed to function as a voltage sensor. We used the patch clamp technique to investigate Na channel mutations that substitute or screen an S4II charge in excised membrane patches from *Xenopus* oocytes expressing channels encoded by wildtype rat brain IIA (RBIIA) or single-point mutation cDNAs (K859Q or L860F). Because Na channels were expressed from singular mRNA, they are presumed to represent a single, homogeneous population. However, the initial characterization of wildtype Na currents revealed an unexpected behavior: after excision of membrane patches from the cytosolic environment, there was a unidirectional and time-dependent transition in channel inactivation from slow to fast kinetics, paralleled by alterations in voltage dependence. This suggests that a single sodium Na channel can adopt at least two distinguishable gating modes, whose equilibrium is modified by biochemical processes. Moreover, Na channel characteristics were affected by modification of the molecular structure in the point mutations K859Q and L860F. Both mutants affect the steepness of activation and induce similar shifts in the current-voltage relationship. In addition, steady-state inactivation curves and kinetic rates of activation and inactivation differ considerably. These results challenge the notion that S4 segments exclusively control the activation of Na channels. Rather, it seems that specific locations within the protein may affect multiple features of Na channel function.

[4] Supported by G. Joan Holt, University of Texas Marine Science Institute.

[5] Department of Zoology, University of Hawaii at Mānoa, Honolulu, Hawaii 96822.

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[7] Department of Physiology/CMNS, University of Hawaii at Mānoa, Honolulu, Hawaii 96822.

Predation-induced Defenses in Hard Corals Reduce Susceptibility to Future Predation[8]

DEBORAH J. GOCHFELD[9]

Predators can detect differences in various aspects of prey quality that translate into preferences for certain prey items. In particular, differences in quantity or types of defenses may determine which species, individuals, or parts of a prey item are consumed. Coral-feeding butterflyfishes show distinct preferences for certain coral species and may prefer particular individuals of a species over others. In clonal organisms, such as corals, one consequence of partial predation may be an elaboration of defenses in the remaining portion of the clone, reducing the probability or severity of future predation events. Inducible defenses are common in terrestrial and marine plants but relatively unstudied in clonal invertebrates. Preference tests were performed to determine whether coral-feeding butterflyfishes could distinguish between corals that had or had not been exposed previously to predation. Genetically identical corals were exposed to predation and nonpredation treatments for various periods of time. Preferences were determined directly by counting bites and indirectly by counting head shakes (indicative of distasteful prey items). Butterflyfishes demonstrated significant preferences for corals from the nonpredation treatment after 1 day of exposure to predation, which may have been a result of an obvious reduction in polyp expansion immediately after the predation treatment. After the regeneration period, fish still showed strong preferences for corals from the nonpredation treatment, although there was no longer a visible difference in polyp expansion between treatments. These preferences may be explained in part by the observed increase in nematocyst density in corals from the predation treatment over that of genetically identical control corals.

Hybridization and Polyploidy in the Coral Genus *Acropora*[10]

JEAN C. KENYON[11]

Many species of the scleractinian coral genus *Acropora* spawn gametes on the same night of the year. Spawning by different species typically occurs within hours of each other. Such multispecies spawning events present opportunities for hybridization. Controlled experimental hybridizations involving four parent species were conducted during mass *Acropora* spawning at Magnetic Island, Australia, in October 1992. Viable embryos from three hybrids were cultured and are currently being raised to maturity by Australian colleagues. Hybridization and a clonal life history are two primary conditions associated with development of polyploidy, a chromosomal alteration in which an organism possesses more than two complete chromosome sets. All four parental species involved in the hybridization experiments had 28 chromosomes, as did all three hybrids. Twenty-eight chromosomes is a conserved number in the genus *Acropora*, found for seven additional species studied to date. However, five studied species have chromosome numbers of 24, 30, 30, 42, and 48, which suggests a polyploid series with a basic num-

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[9] Department of Zoology, University of Hawaii at Mānoa, Honolulu, Hawaii 96822.

[10] Supported by Lerner-Gray Fund for Marine Research of the American Museum of Natural History.

[11] Department of Zoology, University of Hawaii at Mānoa, Honolulu, Hawaii 96822.

ber $x = 6$. Polyploidy represents an instantaneous sympatric speciation event, because the polyploid is reproductively isolated from its parents. Interspecific hybridization and polyploidy may have contributed to the notable diversification of this speciose genus.

Early Larval Development of the Endemic Hawaiian Stream Goby, *Lentipes concolor*[12]

DANIEL P. LINDSTROM[13]

Lentipes concolor is one of only five Hawaiian teleost species whose adult phase is spent in fresh water. Eggs of these fish are laid demersally, and it is thought that the larvae are quickly swept into the sea, where they develop for up to 5 months before recruiting back to fresh water. Because of the petitioning of this species for endangered status, a captive breeding and rearing program was initiated. Eggs from captive adult spawns were allowed to hatch, and the larvae were reared in varied feed composition and salinity to determine optimum conditions. Larvae were sampled, photographed, videotaped, and fixed at regular intervals to document development. Results indicate that larval development is enhanced in full-strength seawater and severely hindered in stream water because of apparently insufficient osmoregulatory ability in fresh water. Larvae were reared successfully in seawater up to 21 days using concentrated natural compositions of plankton and monocultures of nutritionally enriched trochophore-stage oyster larvae as first food.

Advantage of Flexible Juvenile Coloration in Two Species of *Labroides* (Pisces: Labridae)[14]

JEFFREY L. MAHON[15]

Juvenile reef fishes often have a color pattern different from that of adults. It has been theorized that this reduces the aggression received by juveniles from adult conspecifics. This was tested in two species of *Labroides* cleaning wrasses in which certain sized individuals can shift quickly back and forth between the adult and juvenile color patterns. Small *Labroides phthirophagus* and *L. dimidiatus* shifted from adult to juvenile coloration when chased by an adult female conspecific. In *L. phthirophagus* the adult females attacked small cleaners more frequently when they displayed the adult color pattern. This indicates an advantage to showing the juvenile coloration. The advantage of showing the adult coloration is demonstrated by the fact that *Dascyllus albisella*, a common reef fish, preferred to pose for the adult-colored *L. phthirophagus*. Even though juvenile coloration in some fishes may reduce aggression received from adults, it also may reduce food availability and make it advantageous to shift to adult coloration as soon as possible.

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[13] Department of Zoology, University of Hawaii at Mānoa, Honolulu, Hawaii 96822.

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[15] Hawaii Institute of Marine Biology, Kaneohe, Hawaii 96744.

Oviductal Sperm Storage Potential in *Hemidactylus frenatus* Lizards (Gekkonidae)

SUSAN MURPHY-WALKER[16]

Hemidactylus frenatus is a subtropical lizard abundant on the island of Oahu, Hawaii. Females appear to produce clutches of two calcareous-shelled eggs throughout the year. Although oviductal sperm storage is known to occur in *H. frenatus*, maximum potential duration and benefits are unclear. Therefore, captive animals were maintained at ambient temperatures and natural lighting for a period of 1 yr. Thirteen male/female pairs were maintained throughout November and December 1991. On 10 January 1992, 11 females were isolated individually from males for the remainder of the study. All eggs were collected and monitored for fertility and viability. Females were not synchronized with regard to egg production. In addition, no single female produced eggs at regular intervals. A range of 3 to 8 weeks separated egg-production intervals during March through September 1992. As many as 10 viable clutches were produced per isolated female throughout that period, for a sperm storage duration of up to 9 months. Seventy percent of all fertile eggs hatched. Hatchlings included males, contraindicating parthenogenesis. Females ceased egg production in October 1992, presumably as a result of cooler temperatures and the inability to thermoregulate beyond the confines of the cages. Oviductal sperm storage may offset the limitations of small clutch size and variable egg-production intervals.

A First Glimpse of the Molecular Phylogeny of Corals[17]

SANDRA L. ROMANO[18]

Classic studies of coral taxonomy have relied exclusively on morphological characters and have suggested that corals are represented by five suborders, which diverged 200–250 million yr ago. I have used molecular techniques to obtain phylogenetic characters, in the form of DNA, that are independent of the variation inherent in coral skeletal morphology. A region of the mitochondrial 16s ribosomal gene was enzymatically amplified from seven species of corals from four suborders. The 536–563 base pair segments of DNA were cloned, sequenced, and then aligned to each other and to outgroups. Parsimony analysis was used to construct a phylogenetic tree from these data. The data support some of the classic views of coral taxonomy in that three species in the family Acroporidae are nearly identical. However, the view that the coral suborders have been distinct for 200 million yr is not supported by these data. One pair of species with very similar sequences (96%) is placed in separate suborders by the traditional scheme. Another pair of species falls at very different places on the phylogenetic tree but is placed in the same suborder on the morphological tree. For this gene region, the overall sequence differences among these corals is low (< 12%) compared with orders of insects separated by 200 million yr (24%), orders of mammals separated by 85 million yr (21%), and families of sea urchins separated by 60 million yr (20%). These data indicate that our view of coral evolution, in terms of tempo and taxo-

[16] Department of Zoology, University of Hawaii at Mānoa, Honolulu, Hawaii 96822.

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[18] Department of Zoology, University of Hawaii at Mānoa, Honolulu, Hawaii 96822. Sponsor: S. R. Palumbi.

nomic hierarchy, is flawed. Continued research holds great promise for clarifying our understanding of the evolutionary history of corals.

Scales of Habitat Selection by Foraging 'Elepaio in Undisturbed and Human-altered Forests in Hawai'i

ERIC A. VANDERWERF[19]

I examined habitat selection by foraging 'Elepaio (*Chasiempis sandwichensis*) in relatively undisturbed and human-altered forests in Hawai'i at three hierarchically nested scales by comparing sites where birds foraged with random sites. The fine scale was based on a sphere with a radius of 0.75 m, the intermediate scale used a cylinder from ground to canopy with a radius of 1.5 m, and the broad scale was based on the point-quarter method. At a fine scale, 'Elepaio in both forests selected foraging sites with high foliage density, large bark surface area, and many twigs and small branches. 'Elepaio in disturbed areas compensated for lower available foliage density by being "hyperselective" toward high-density sites. At an intermediate scale, 'Elepaio in both habitats favored sites with above-average foliage density at all heights. Birds in undisturbed habitat preferred sites with native ground cover and used sites with feral pig damage or exotic grasses less than expected, but birds in disturbed forest did not favor any ground cover type. At a broad scale, tree and shrub densities were much lower in disturbed areas, but 'Elepaio did not select sites with high tree or shrub density in either habitat. 'Elepaio in both habitats preferred 'Ōhi'a and used Koa less than expected. Disturbed areas may be lower-quality foraging habitat because less space consists of sites with preferred high fine-scale foliage density. The broad scale is commonly used to measure habitat around nest sites and song perches, but it did not detect patterns of foraging site selection and may be inappropriate for measuring avian foraging habitat.

Changes in Whole-body Thyroxine and Triiodothyronine Concentrations and Total Content during Early Development and Metamorphosis of the Toad *Bufo marinus*[20]

GREGORY M. WEBER,[21] EUGENIA FARRAR,[21,22] CHRIS K. F. TOM,[21] AND E. GORDON GRAU[21]

Thyroid hormones play a central role in vertebrate development and are pivotal in the stimulation of amphibian (anuran) metamorphosis. Based on evidence from four species, thyroid hormones appear to rise during the onset of metamorphosis. Little is known about the possible roles or sources of thyroid hormones in amphibians before thyroidal development. We examined changes in thyroxine (T_4) and triiodothyronine (T_3) during the early development and metamorphosis of the toad *B. marinus*. Both total hormone content and concentrations of T_3 and T_4 were calculated to assess whether changes in these hor-

[19] Department of Zoology, University of Hawaii at Mānoa, Honolulu, Hawai'i 96822.

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[21] Department of Zoology, University of Hawaii at Mānoa, Honolulu, Hawaii 96822.

[22] Department of Zoology and Genetics, Iowa State University, Ames, Iowa 50011.

mones might derive from changes in body weight and/or water content rather than from changes in thyroid hormone secretion and/or metabolism. Generally, both total content and concentrations of the two hormones varied in parallel. Overall, although individual weight and water changes affected the magnitude of hormone changes, they appeared to have little input into their direction. Both thyroid hormones were elevated at gastrulation (1 day after fertilization), but declined to low levels within the first week. This is the first report of thyroid hormones in anuran embryos before thyroidal differentiation. This suggests that thyroid hormones are deposited in the anuran egg during oogenesis in a manner that is similar to that described for teleost fishes. Levels of T_3 and T_4 began to rise at about 2 weeks after fertilization (stage 31 [staged according to Limbaugh and Volpe, 1957, Am. Mus. Novit. 1842:1–31]) and peaked during early metamorphic climax (stage 43). This pattern coincides well with the notion that thyroid hormones are central regulators of metamorphosis in *B. marinus* as in other amphibians examined to date.